Technical Memorandum
Draft Baseline State for Macroinvertebrates in Taranaki Rivers

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Purpose

The purpose of this memorandum is to provide an assessment of the baseline state of macroinvertebrate attributes as a measure of ecosystem health, as required by the National Policy Statement for Freshwater Management 2020 (NPS-FM).

Overview of macroinvertebrates

Freshwater macroinvertebrates are a range of aquatic species that play a crucial role in freshwater ecology, as they respond to changes in a number of environmental variables including water quality, hydrology, and habitat. A water sample collected from a waterbody will reveal the water chemistry at the time of sampling and thus give an indication of pressures on the ecology of the stream, while assessing the state of the freshwater macroinvertebrates will show the cumulative influences of these factors over the recent past and be a primary indicator of whether a stream is healthy.

Benthic macroinvertebrates are used worldwide as sub-indicators of stream ecosystem health as they respond to human pressures, are taxonomically diverse, and easy to sample. Macroinvertebrate indices are responsive to multiple stressors, but not all stressors, and as such provide a good indicator of the overall condition of the macroinvertebrate component of stream ecosystem health (Clapcott et al, 2017). They play an important role in the stream ecosystem food web and are influenced by the physical, chemical, and biological conditions of the stream. They also respond to changes in variables including, but not exclusive to, water quality, flow, stream habitat, and invasive species. Thus, they are capable of showing the impacts of stressors present upstream in the catchment, such as habitat loss or pollution (NEMS, 2022). For example, when effluent is discharged into a stream, intolerant organisms reduce in numbers or disappear, while those that are able to tolerate such stresses increase in number.

Macroinvertebrates and the National Objectives Framework

The NPS-FM sets out requirements for councils and communities to maintain or improve freshwater (where it is degraded). It includes a National Objectives Framework (NOF) that specifies nationally applicable

standards for particular freshwater parameters (referred to as 'attributes') for both rivers and lakes. Macroinvertebrates (1 and 2) include three measures within two attributes that apply to rivers.

To measure the state of health of different macroinvertebrates, "biotic indices" have been developed to make them easier to understand. These include the macroinvertebrate community index (MCI), quantitative macroinvertebrate community index (QMCI), and average score per metric (ASPM) (NPS-FM Appendix 2B, Tables 14 and 15) which are used to assist in determining the ecological health of waterbodies.

The NOF has defined four attribute bands and descriptions (A to D) for these macroinvertebrate attributes. These bands indicate the level to which the macroinvertebrate attribute is provided for, ranging from band A (indicative of pristine conditions) to band D (indicative of severe pollution or nutrient enrichment).

Macroinvertebrate Community Index (MCI)

The MCI uses presence-absence macroinvertebrate taxa data, and is calculated by averaging the assigned tolerance scores of taxa present at a site and multiplying this by a scale factor of 20. The NPS-FM states that this must be assessed using the methods defined in Stark and Maxted (2007), which also has an associated taxa list and tolerance scores. This however, excludes sites for which the deposited sediment attribute does not apply, which require use of the soft-sediment sensitivity scores and taxonomic resolution defined in Clapcott *et al.* (2017).

Quantitative Macroinvertebrate Community Index (QMCI/SQMCI)

The QMCI is the quantitative variant of the MCI, so also accounts for the relative abundance of taxa present at a site. Note that while the NPS-FM requires QMCI as a numeric attribute state for macroinvertebrates, Taranaki Regional Council (TRC) uses the semi-quantitative MCI value (SQMCI), which provides a similar output and will be considered surrogate to QMCI in relation to the NPS-FM. Unlike the MCI, the SQMCI is not multiplied by a scaling factor of 20, thus provides a smaller numerical output. This attribute uses the same methods applied as those applied to the MCI score, both of which are shown in Table 1.

Table 1: NOF Attribute – Macroinvertebrates (1 of 2). Source: MfE, 2020.

Value (and component)	Ecosystem health (aquatic life)	
Freshwater body type	Wadeable rivers	
Attribute unit	Macroinvertebrate Community Index (MCI) score; Quantitative Macroinvertebrate Community Index (QMCI) score	
Attribute band and description	**Numeric attribute states**	
	QMCI	MCI
A Macroinvertebrate community, indicative of pristine conditions with almost no organic pollution or nutrient enrichment.	≥6.5	≥130
B Macroinvertebrate community indicative of mild organic pollution or nutrient enrichment. Largely composed of taxa sensitive to organic pollution/nutrient enrichment.	≥5.5 and <6.5	≥110 and <130
C Macroinvertebrate community indicative of moderate organic pollution or nutrient enrichment. There is a mix of taxa sensitive and insensitive to organic pollution/nutrient enrichment.	≥4.5 and <5.5	≥90 and <110
National bottom line	**4.5**	**90**
D	<4.5	<90

Macroinvertebrate community indicative of severe organic pollution or nutrient enrichment. Communities are largely composed of taxa insensitive to inorganic pollution/nutrient enrichment.		
MCI and QMCI scores to be determined using annual samples taken between 1 November and 30 April with either fixed counts with at least 200 individuals, or full counts, and with current state calculated as the five-year median score. All sites for which the deposited sediment attribute does not apply, whether because they are in river environment classes shown in Table 25 in Appendix 2C or because they require alternate habitat monitoring under clause 3.25 are to use soft sediment sensitivity scores and taxonomic resolution as defined in table A1.1 in Clapcott et al. 2017 Macroinvertebrate metrics for the National Policy Statement for Freshwater Management. Cawthron Institute: Nelson, New Zealand. (see clause 1.8). MCI and QMCI to be assessed using the method defined in Stark JD, and Maxted, JR. 2007 A user guide for the Macroinvertebrate Community Index. Cawthron Institute: Nelson, New Zealand (See Clause 1.8), except for sites for which the deposited sediment attribute does not apply, which require use of the soft-sediment sensitivity scores and taxonomic resolution defined in table A1.1 in Clapcott et al. 2017 Macroinvertebrate metrics for the National Policy Statement for Freshwater Management. Cawthron Institute: Nelson, New Zealand. (see clause 1.8).		

Average Score Per Metric (ASPM)

The ASPM uses a multiple index metric that combines MCI, EPT number, and the percentage of EPT individuals present (%EPT). EPT stands for Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) which are three pollution sensitive (intolerant) macroinvertebrate orders. The ASPM standardises these three metrics by dividing values by the maximum values to obtain a value between 0 and 1. The NPS-FM states that the method described by Collier (2008) should be used to normalise ASPM scores. The ASPM attribute is set out below in Table 2.

Table 2: National objectives framework attribute Table 15 – Macroinvertebrates (2 of 2). Source: MfE, 2023.

Value (and component)	Ecosystem health (aquatic life)
Freshwater body type	Wadeable rivers
Attribute unit	Macroinvertebrate Average Score Per Metric (ASPM)
Attribute band and description	**Numeric attribute states ASPM score**
A Macroinvertebrate communities have high ecological integrity, similar to that expected in reference conditions.	≥0.6
B Macroinvertebrate communities have mild-to-moderate loss of ecological integrity	<0.6 and ≥0.4
C Macroinvertebrate communities have moderate-to severe loss of ecological integrity.	<0.4 and ≥0.3
National Bottom Line	**0.3**
D Macroinvertebrate communities have severe loss of ecological integrity.	**<0.3**
ASPM scores to be determined using annual samples taken between 1 November and 30 April with either fixed counts with at least 200 individuals, or full counts, and with current state calculated as the five-year median score. All sites for which the deposited sediment attribute does not apply, whether because they are in river environment classes shown in Table 25 in Appendix 2C or because they require alternate habitat monitoring under clause 3.25, are to use soft-sediment sensitivity scores and taxonomic resolution as defined in table A1.1 in Clapcott et al. 2017. Macroinvertebrate metrics for the National Policy Statement for Freshwater Management. Cawthron Institute: Nelson, New Zealand. (see clause 1.8) When normalising scores for the ASPM, use the following minimums and maximums: %EPT-abundance (0-100), EPT-richness (0-29), MCI (0-200) using the method of Kevin J Collier (2008). Average score per metric: An alternative metric aggregation	

method for assessing wadeable stream health. New Zealand Journal of Marine and Freshwater Research, 42:4, 367-378, DOI: 10.1080/00288330809509965. (see clause 1.8)

Macroinvertebrate monitoring in the Taranaki region

Macroinvertebrates are monitored annually (from 1 July to 30 June) under the Council's state of environment monitoring (SoE) programme. This programme was initiated in 1995, and the methodology has remained relatively unchanged since that time. Various sites have been added and removed from the programme since it commenced, with a total of 67 sites currently monitored.

Traditionally, monitoring surveys were performed twice during the monitoring year, once during spring (October to January) and once during summer (February to May). Following an assessment of the monitoring data, it was determined that it would be appropriate to discontinue spring surveys and undertake a single survey during the summer months, in alignment with NOF requirements. Because of the length of the data record and consistency in methodology, the programme has collected statistically complete and robust data. Additionally, due to the length of the dataset, it is capable of reliably detecting long term trends.

Baseline states for macroinvertebrates

The NPS-FM requires all regional councils to identify the baseline states of all attributes described in Appendix 2A and 2B of the NPS-FM within each Freshwater Management Unit (FMU). When compared against national bottom lines and the relevant objectives for an FMU, baselines provide the reference point from which councils must either maintain or improve an attribute. This in turn will contribute toward achieving freshwater objectives for each compulsory and non-compulsory value. Waterbodies must not be allowed to degrade, or remain below an identified baseline state unless that state is determined to be naturally occurring.

Under Clause 1.4 of the NPS-FM, the baseline state, in relation to an attribute, is the best state out of the following:

a) the state of the attribute on the date it is first identified by a regional council under Clause 3.10(1)(b) or (c);

b) the state of the attribute on the date on which a regional council set a freshwater objective for the attribute under the National Policy Statement for Freshwater Management 2014 (as amended in 2017);

c) the state of the attribute on 7 September 2017.

The Council has not previously set freshwater objectives under the NPS-FM 2014 (amended 2017) for macroinvertebrates, so the state of the attribute under 1.4 (b) could not be calculated, and was excluded from identification of baseline. Therefore, the best state out of Clause 1.4 (a) and (c) were used to identify the baseline states of each of the macroinvertebrates attributes.

The above approach provided for the inclusion of data at monitoring sites collected both before and after 2017. It is important to note that due to having different NOF band values and NOF band descriptions (and therefore different calculation methods), baseline state setting for MCI, SQMCI, and ASPM have been treated as independent entities when selecting best state. This means that for some sites, for example, the MCI baseline value may have been identified applying sub-clause 1.4(a) while for the same site SQMCI and ASPM may have been identified applying sub-clause 1.4(c).

Under Clause 1.6 of the NPS-FM, local authorities must use the best information available at the time (and if practicable, using complete and robust data) to give effect to the NPS-FM. In the absence of complete and robust data, the best information available should be used. This may include modelling, partial data, and local

knowledge, and preferably use sources that provide the greatest level of certainty (or take all practicable steps necessary to reduce uncertainty).

Under the NPS-FM, macroinvertebrates are associated with the Ecosystem Health value, which is a compulsory value within the NOF (NPS-FM, Appendix 1A). Macroinvertebrates are included in the NOF as Appendix 2B attributes, requiring the development of an action plan. It is necessary for baseline states to be identified by TRC for the Taranaki region to ensure that target attribute states are set at a level that either achieve or exceed the best baseline state for that attribute and (at a minimum) achieve the national bottom line.

The remainder of this memo summarises the monitoring and work carried out by TRC to identify baseline states for macroinvertebrates in the region's rivers.

Criteria for identifying site-based baseline states for macroinvertebrates in rivers

Draft baseline states for macroinvertebrates have been identified for individual monitoring sites. These site-specific baseline states correspond to the NOF attribute bands set out in NPS-FM, Table 14 and 15, and have been identified using data from the SoE monitoring programme. Representativeness of these sites and attribute bands within each Freshwater Management Unit (FMU) are also critically discussed.

The NPS-FM requires MCI, QMCI, and ASPM scores be determined using annual samples taken between 1 November and 30 April, with the current state being calculated as the median of those annual samples across a five-year period. The SoE programme at TRC does not align with this monitoring period, therefore there is often data from more than one survey per year. To overcome this, the criteria for one monitoring year was set as 01 November – 31 October (i.e., the data for the year 2013, for example, is data collected between 1 November 2012 and 31 October 2013). Due to monitoring traditionally being carried out twice a year, with variable date ranges, the five year median was calculated using years with multiple data points. In this case, the median of all data points for each individual year was determined first, and then the five-year median was calculated across the five year period being assessed (so n remains 5).

Additionally, for MCI and QMCI scoring, the NPS-FM requires either fixed counts with at least 200 individuals, or full counts. TRC uses coded abundance, which is a semi-quantitative method that provides coded abundance data on a 5-point scale. The numeric attribute states have been calculated with data derived using this methodology. This is deemed both appropriate and robust, given the long period in which the SoE programme has been carried out. As already noted, SQMCI values will be used as a surrogate for QMCI values, and baseline states will be set using the SQMCI data.

Due to the SoE programme having various sites both added and removed from the programme over the years, the five year medians will be calculated from the 67 current sites in the SoE programme. For the newly added SoE sites, the data will not fit under the requirements of Clause 1.4 of the NPS-FM. For these sites, it is recommended that incomplete/partial data (NPS-FM, Clause 1.6) be included in the identification of site-specific baseline states, as the monitoring for these sites will continue on a long-term basis. In the future these sites will have data which will be considered complete and scientifically robust in assessing progress toward target attribute states.

Site-based baseline states

A total of 58 sites had scientifically complete and robust data available to calculate baseline state, with the remaining nine sites using partial or incomplete data in the calculations.

There was notable variability between sites and NOF bands for each numeric state. For MCI, 59 out of 67 sites (88%) were graded band A-C however, it is noted that over half the sites (37 sites, 55%) only achieved band C, with eight sites (12%) failing to achieve the national bottom line (band D).

For the SQMI measure, around one third of the sites (22 sites, 33%) achieved band A, while 8 sites (12%) achieved band B, and 20 sites (30%) achieved band C. A quarter of the sites (17 sites, 25%) failed to achieve the national bottom line; the highest proportion of sites failing to achieve national bottom lines across all metrics assessed. This could reflect the sensitive nature of the SQMCI metric compared to MCI. MCI is calculated using presence-absence data, therefore any change in this metric reflects the loss or addition of taxa at a site, and therefore will always reflect a decline in relative abundance before values decline. The SQMCI and QMCI both take relative abundances into account, so are more sensitive to changes in macroinvertebrate communities that don't necessarily reduce the number of taxa present at a site.

For the ASPM attribute, a total of 62 sites (93%) were graded in band A-C. The ASPM attribute had the lowest proportion of sites failing to achieve the national bottom-line across all metrics, with only five out of the 67 sites (7%) being in band D.

When all numeric states are collated, 22 sites (32%) have at least one numeric state that fails to achieve the national bottom-line.

A summary of the proportions of monitored sites within each NOF band (band A to D) is described in Table 3, while the site-based baseline states are summarised in Table 4. The percentage of SoE monitored sites in each FMU within each NOF attribute band is also summarised in Table 3. Site locations within each NOF band are in Figures 1 -3.

Table 3: Number and percentage of the 67 SoE monitoring sites within each NOF band for each macroinvertebrate numeric attribute state.

NOF BAND	MCI		SQMCI		ASPM	
	Sites	%	Sites	%	Sites	%
A	13	19%	22	33%	12	18%
B	9	13%	8	12%	27	40%
C	37	55%	20	30%	23	34%
D	8	12%	17	25%	5	7%

Table 4: Site-based baseline state for the macroinvertebrate attribute derived from monitored data at 67 monitoring sites in the Taranaki region. Sites with an asterisk (*) indicates where partial/incomplete data is used for baseline states setting.

FMU	Site code	Clause 1.4(a) - from record starting date				Clause 1.4(c) - September 2017				MCI NOF Band	SQMCI NOF Band	ASPM NOF Band
		n	MCI	SQMCI	ASPM	n	MCI	SQMCI	ASPM			
Southern Hill Country	*MMK000050	3	89	4.9	0.3	ND	ND	ND	ND	D	C	C
Southern Hill Country	TNH000090	5	101.5	5.5	0.39	5	109.5	6.65	0.445	C	A	B
Southern Hill Country	TNH000200	5	109	6.05	0.47	5	107	6.1	0.475	C	B	B
Southern Hill Country	TNH000515	5	93.5	4.25	0.365	5	97	4.2	0.36	C	D	C
Southern Hill Country	*WIU000700	2	75.75	4.525	0.1575	ND	ND	ND	ND	D	C	D
Southern Hill Country	WNR000450	5	90	4.4	0.3	ND	ND	ND	ND	C	D	C
Coastal Terraces	MGT000488	5	89	3.9	0.23	5	83	4.5	0.22	D	C	D
Coastal Terraces	MGT000520	5	57	1.8	0.09	5	74	3.05	0.2	D	D	D
Coastal Terraces	*MRO000210	2	76	4.725	0.1625	ND	ND	ND	ND	D	C	D
Coastal Terraces	WAI000110	5	88	4.4	0.35	5	93	4.6	0.37	C	C	C
Pātea	MGH000950	5	81	3.6	0.28	5	96	4.7	0.39	C	C	C
Pātea	*MKR000495	3	96	5.1	0.38	ND	ND	ND	ND	C	C	C
Pātea	PAT000200	5	143.5	7.7	0.73	5	146	8.1	0.72	A	A	A
Pātea	PAT000315	5	108	5.2	0.48	5	120.5	7.5	0.55	B	A	B
Pātea	PAT000360	5	101	3.8	0.36	5	100	4.6	0.42	C	C	B
Volcanic Ringplain	HRK000085	5	84	3.7	0.31	5	99	4.2	0.365	C	D	C
Volcanic Ringplain	HTK000350	5	89	3.65	0.335	5	106	6.5	0.44	C	A	B
Volcanic Ringplain	HTK000425	5	103	4.55	0.44	5	110	7	0.46	B	A	B
Volcanic Ringplain	HTK000745	5	88	3.55	0.33	5	89	3.7	0.285	D	D	C
Volcanic Ringplain	KPA000250	5	96	2.7	0.38	5	133.5	6.8	0.615	A	A	A

FMU	Site code	Clause 1.4(a) - from record starting date				Clause 1.4(c) - September 2017				MCI NOF Band	SQMCI NOF Band	ASPM NOF Band
		n	MCI	SQMCI	ASPM	n	MCI	SQMCI	ASPM			
Volcanic Ringplain	KPA000700	5	96.5	2.5	0.365	5	105	5.4	0.45	C	C	B
Volcanic Ringplain	KPA000950	5	81	3.05	0.29	5	89	3.3	0.3	D	D	C
Volcanic Ringplain	KPK000250	5	139	7.3	0.66	5	138	8.3	0.6	A	A	A
Volcanic Ringplain	KPK000500	5	107	4.9	0.48	5	121	5.5	0.52	B	B	B
Volcanic Ringplain	KPK000660	5	80.5	2.85	0.255	5	106	4.8	0.43	C	C	B
Volcanic Ringplain	KPK000880	5	84	3.05	0.265	5	90	4.1	0.33	C	D	C
Volcanic Ringplain	KPK000990	5	92	2.65	0.34	5	90	2.7	0.32	C	D	C
Volcanic Ringplain	KTK000150	5	142	7.55	0.74	5	136.5	7.5	0.6	A	A	A
Volcanic Ringplain	KTK000248	5	109	4.7	0.43	5	106	4.35	0.43	C	C	B
Volcanic Ringplain	MGE000970	5	107.5	4.6	0.49	5	105	4.65	0.45	C	C	B
Volcanic Ringplain	MRK000420	5	79.5	3.4	0.26	5	95	4.8	0.39	C	C	C
Volcanic Ringplain	MWH000490	5	81	3.3	0.32	5	93	4.2	0.37	C	D	C
Volcanic Ringplain	PNH000200	5	127.5	6.4	0.56	5	135	7.7	0.62	A	A	A
Volcanic Ringplain	PNH000900	5	75	3.2	0.21	5	92	5.5	0.36	C	B	C
Volcanic Ringplain	STY000300	5	131	6.9	0.455	5	120	7.75	0.43	A	A	B
Volcanic Ringplain	STY000400	5	121.5	6.7	0.455	5	126	7.7	0.48	B	A	B
Volcanic Ringplain	TMR000150	5	148	7.35	0.67	5	146	7.9	0.725	A	A	A
Volcanic Ringplain	TMR000375	5	99.5	4.05	0.41	5	110	5.4	0.51	B	C	B
Volcanic Ringplain	WGA000260	5	93	3.8	0.32	5	101	5	0.42	C	C	B

FMU	Site code	Clause 1.4(a) - from record starting date				Clause 1.4(c) - September 2017				MCI NOF Band	SQMCI NOF Band	ASPM NOF Band
		n	MCI	SQMCI	ASPM	n	MCI	SQMCI	ASPM			
Volcanic Ringplain	WGA000450	5	76.5	3.2	0.21	5	91	4	0.34	C	D	C
Volcanic Ringplain	WGG000115	5	138	7.7	0.685	5	142	8.4	0.7	A	A	A
Volcanic Ringplain	WGG000150	5	139	7.4	0.63	5	132	7.9	0.59	A	A	A
Volcanic Ringplain	WGG000500	5	92	3.9	0.32	5	115	6.8	0.45	B	A	B
Volcanic Ringplain	WGG000665	5	95	4.2	0.36	5	105	5.4	0.4	C	C	B
Volcanic Ringplain	WGG000895	5	90	3.9	0.33	5	96.5	4.3	0.38	C	D	C
Volcanic Ringplain	WGG000995	5	81	3.5	0.26	5	91	3.8	0.32	C	D	C
Volcanic Ringplain	WKH000100	5	135.5	7.7	0.64	5	141	7.85	0.61	A	A	A
Volcanic Ringplain	WKH000500	5	105	4.35	0.46	5	120.5	5.9	0.55	B	B	B
Volcanic Ringplain	WKH000920	5	86	3.2	0.285	5	96	3.7	0.315	C	D	C
Volcanic Ringplain	WKH000950	5	91	3.65	0.285	5	90	3.55	0.31	C	D	C
Volcanic Ringplain	WKR000500	5	98	5.8	0.41	5	108	6.9	0.45	C	A	B
Volcanic Ringplain	WKR000700	5	104	6.3	0.435	5	104	6.5	0.43	C	A	B
Volcanic Ringplain	WMK000100	5	137	7.7	0.615	5	137.5	7.9	0.605	A	A	A
Volcanic Ringplain	WMK000298	5	96	2.9	0.39	5	100	4.4	0.39	C	D	C
Waitara	KRP000300	5	90	3.5	0.23	5	107	5.7	0.4	C	B	B
Waitara	KRP000660	5	77	3.1	0.17	5	102	5.5	0.43	C	B	B
Waitara	*MAA000900	3	97	4.35	0.365	ND	ND	ND	ND	C	D	C
Waitara	MGN000195	5	134.5	7.2	0.51	5	136.5	7.4	0.61	A	A	A
Waitara	MGN000427	5	99.5	3.6	0.39	5	104	5.6	0.43	C	B	B
Waitara	MKW000200	5	139	7.55	0.65	5	137.5	7.7	0.62	A	A	A

FMU	Site code	Clause 1.4(a) - from record starting date				Clause 1.4(c) - September 2017				MCI NOF Band	SQMCI NOF Band	ASPM NOF Band
		n	MCI	SQMCI	ASPM	n	MCI	SQMCI	ASPM			
Waitara	MKW000300	5	108	3	0.45	5	119	6.8	0.525	B	A	B
Waitara	*MTA000068	3	112	5.25	0.465	ND	ND	ND	ND	B	C	B
Waitara	WTR000540	5	102	4.55	0.435	ND	ND	ND	ND	C	C	B
Waitara	WTR000850	5	89	3.6	0.31	5	90.5	2.95	0.33	C	D	C
Northern Hill Country	*MNT000950	2	76.75	4.675	0.14	ND	ND	ND	ND	D	C	D
Northern Hill Country	*URU000198	3	95.5	4.8	0.37	ND	ND	ND	ND	C	C	C
Northern Hill Country	*WMR000100	2	106.75	5.925	0.4025	ND	ND	ND	ND	C	B	B

Table 5: FMU-based baseline states for the macroinvertebrate numeric attribute states (MCI, SQMCI, ASPM) expressed as percentage of SoE monitored sites in each FMU within each NOF attribute band.

NOF Band	Total number of sites	MCI				SQMCI				ASPM			
		A	B	C	D	A	B	C	D	A	B	C	D
Southern Hill Country	6	0.0%	0.0%	66.7%	33.3%	16.7%	16.7%	33.3%	33.3%	0.0%	33.3%	50.0%	16.7%
Coastal Terraces	4	0.0%	0.0%	25.0%	75.0%	0.0%	0.0%	75.0%	25.0%	0.0%	0.0%	25.0%	75.0%
Pātea	5	20.0%	20.0%	60.0%	0.0%	40.0%	0.0%	60.0%	0.0%	20.0%	40.0%	40.0%	0.0%
Volcanic Ringplain	39	25.6%	15.4%	53.8%	5.1%	41.0%	7.7%	20.5%	30.8%	23.1%	41.0%	35.9%	0.0%
Waitara	10	20.0%	20.0%	60.0%	0.0%	30.0%	30.0%	20.0%	20.0%	20.0%	20.0%	60.0%	0.0%
Northern Hill Country	3	0.0%	0.0%	66.7%	33.3%	0.0%	33.3%	66.7%	0.0%	0.0%	33.3%	33.3%	33.3%

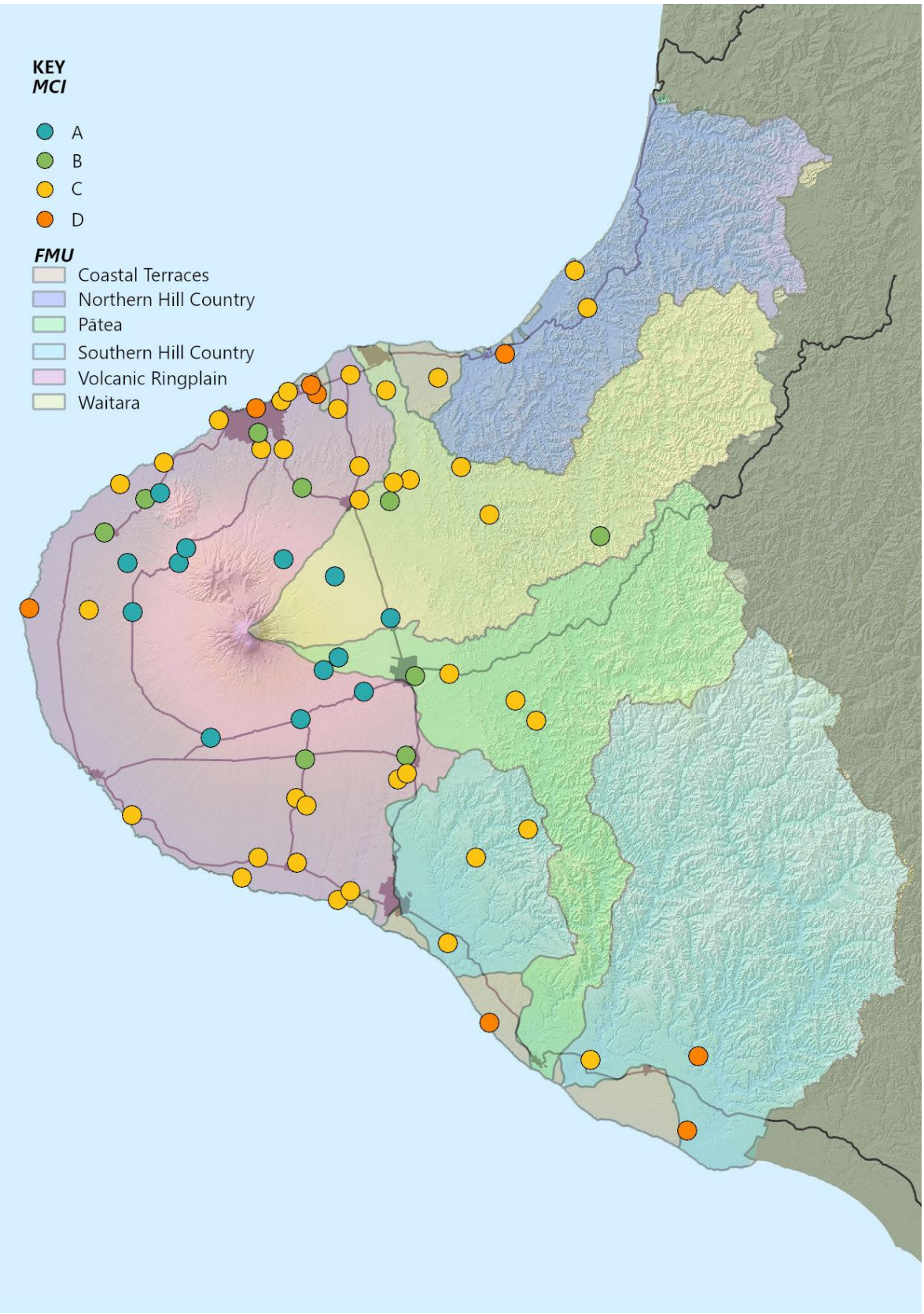

Figure 1: Site-based baseline state for the macroinvertebrate MCI attribute derived from monitored data at 67 monitoring sites in the Taranaki region.

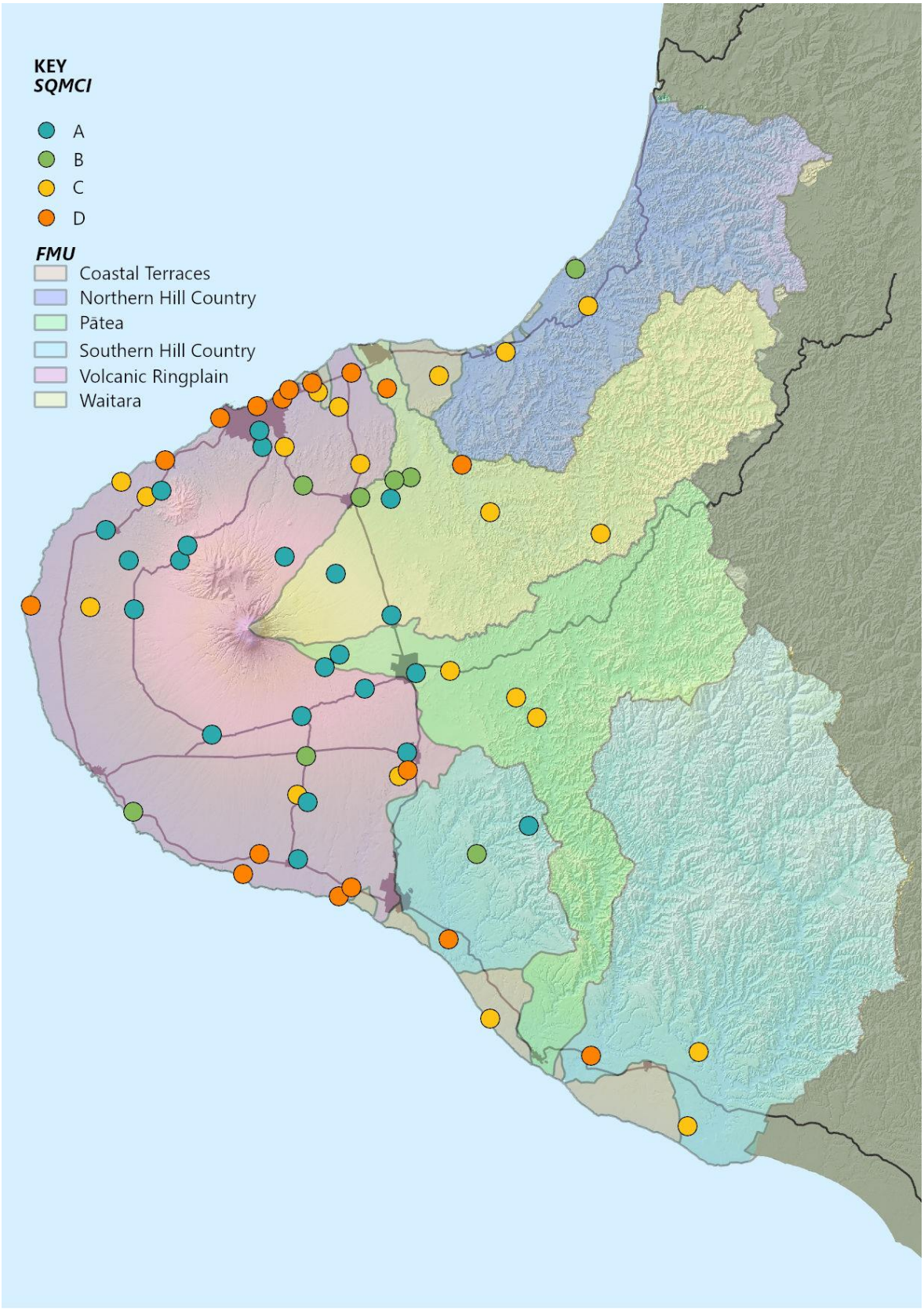

Figure 2: Site-based baseline state for the macroinvertebrate SQMCI attribute derived from monitored data at 67 monitoring sites in the Taranaki region.

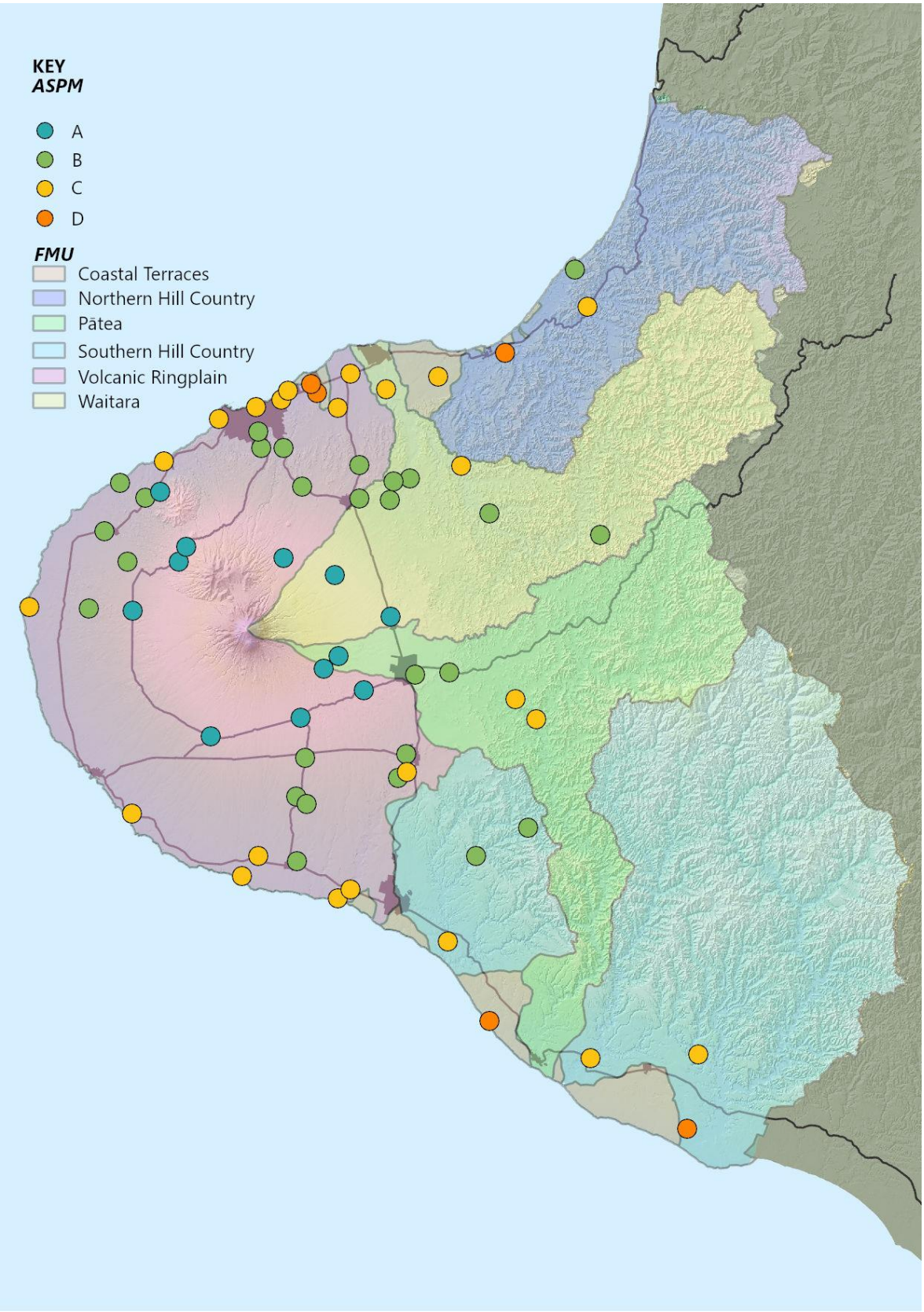

Figure 3: Site-based baseline state for the macroinvertebrate ASPM attribute derived from monitored data at 67 monitoring sites in the Taranaki region.

Baseline period and temporal state variability

This baseline assessment has been carried out using data that demonstrates the best state, out of the baseline periods defined in the NPS-FM. The council has not previously set freshwater objectives for macroinvertebrate attributes, and therefore sub-clause 1.4(b) is not applicable. Details of these baseline data ranges are included in Table 4. It is important to reiterate that the three numeric attribute states for macroinvertebrates have been treated independently when identifying baseline states.

Of the 67 SoE monitoring sites, most have long-term records, having been sampled since the late 1990's or early 2000's. Nine sites were recently added to the programme and therefore did not have five years of data available. For these sites partial/incomplete data were used to form a baseline. Additionally, two sites did not have five years of data prior to 2017 so could not fulfil the requirement of sub-clause 1.4(c). For these two sites, a more recent five year data range was the only option to form a baseline so still fulfilled sub-clause 1.4(a). In summary:

- For MCI, 25 sites reflected the best state seen as the earliest five years of available data (sub-clause 1.4(a)). For the remaining 42 sites, the best state was seen in the five years of data to 2017 (sub-clause 1.4(c)).
- For SQMCI, 16 sites reflected the best state seen as the earliest five years of available data (sub-clause 1.4(a)). For the remaining 51 sites, the best state was seen in the five years of data to 2017 (sub-clause 1.4(c)).
- For ASPM, 27 sites reflected the best state seen as the earliest five years of available data (sub-clause 1.4(a)). For the remaining 40 sites, the best state was seen in the five years of data to 2017 (sub-clause 1.4(c)).

While it is a requirement of the NPS-FM to select the 'best' state when assessing baselines, it is important to understand how representative that baseline is in terms of the variability of the data at a given site.

In the case of macroinvertebrate attributes set out in the NOF, the record length for grading a site should be 5 years. An assessment is necessary to determine if the selected 5-year period is broadly representative of the overall dataset (and therefore meaningful), or whether the natural temporal variability in the data is such that the attribute grading is continuously shifting and therefore the selected baseline is, in a sense, arbitrary.

The rolling state for NOF attribute bands for MCI, QMCI, and ASPM at a subset of sites (sites which have long-term data) have been calculated by Land Water People (LWP) (Fraser, 2022). Note that this analysis of state over time uses TRC compliance river quality data, so may not include all of the SoE sites in the current monitoring programme. However, it still provides useful insight in determining whether 5-year periods can be representative of an overall dataset. The results are presented in Figure 4, Figure 5 and Figure 6.

An evaluation of the rolling 5-year states show that although most sites show changes in attribute grades over the entire data set, these shifts mostly occur up and down between two consecutive grades (e.g., from B to C and back to B). This is not unexpected, given that the numeric values that inform the grading can often sit close to the boundary between two grades and the sensitivity of some numeric attribute states such as QMCI. Some sites recorded more than two grades over the entire data range. This is more noticeable in the QMCI metric but is also present in MCI and ASPM results. These changes often occur in an overall positive direction (i.e. improving from band D to band C or B). This is more likely a reflection of meaningful long-term environmental change rather than natural variability over a shorter time period. Overall, these results increase our confidence that the 5-year baseline periods that are used for the baseline assessment are appropriate and are not undermined by temporal variability in our datasets.

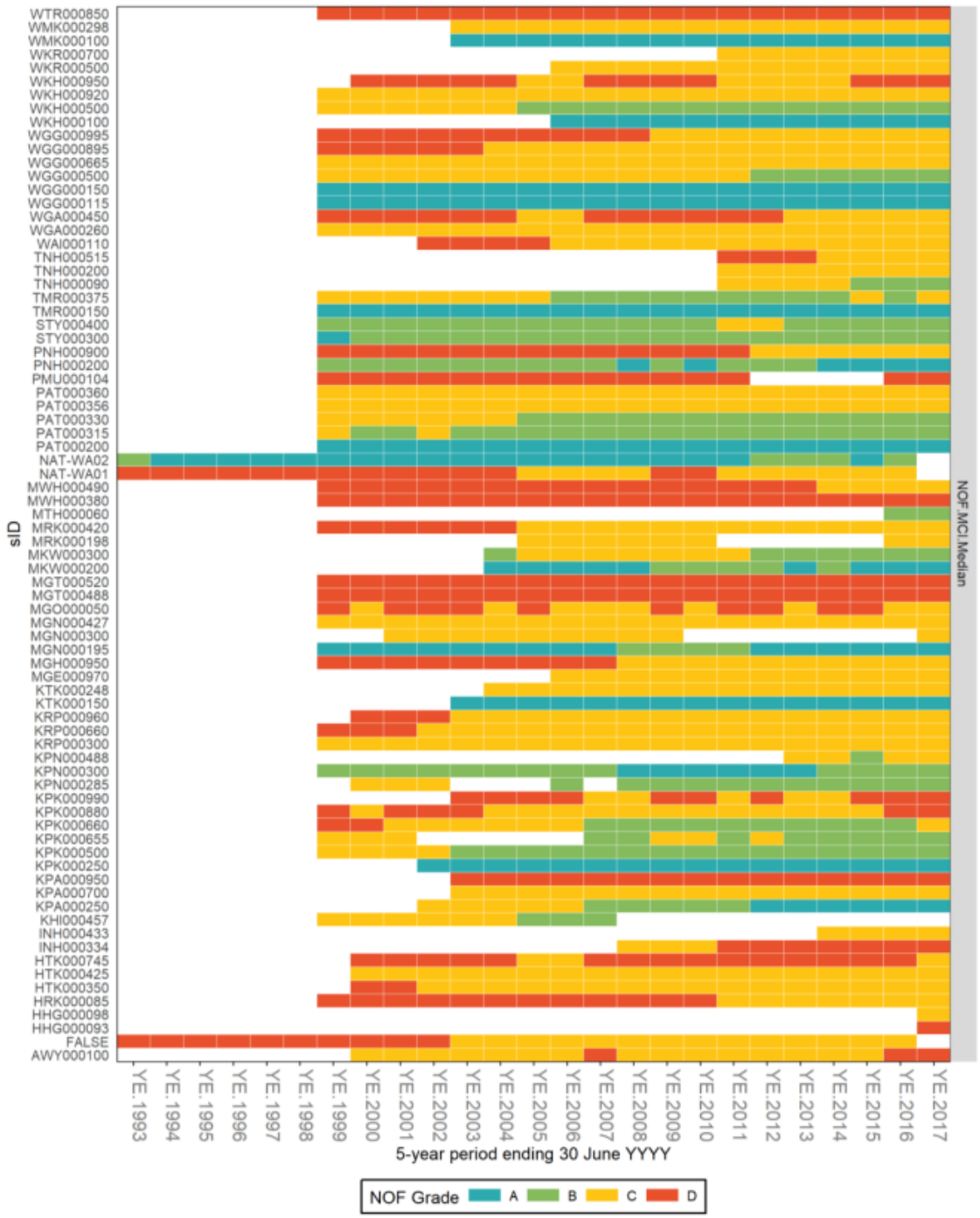

Figure 4: Temporal variation in NOF attribute bands for MCI at a sub-set of monitoring sites from 1993 to 2017. Source: Fraser, 2022.

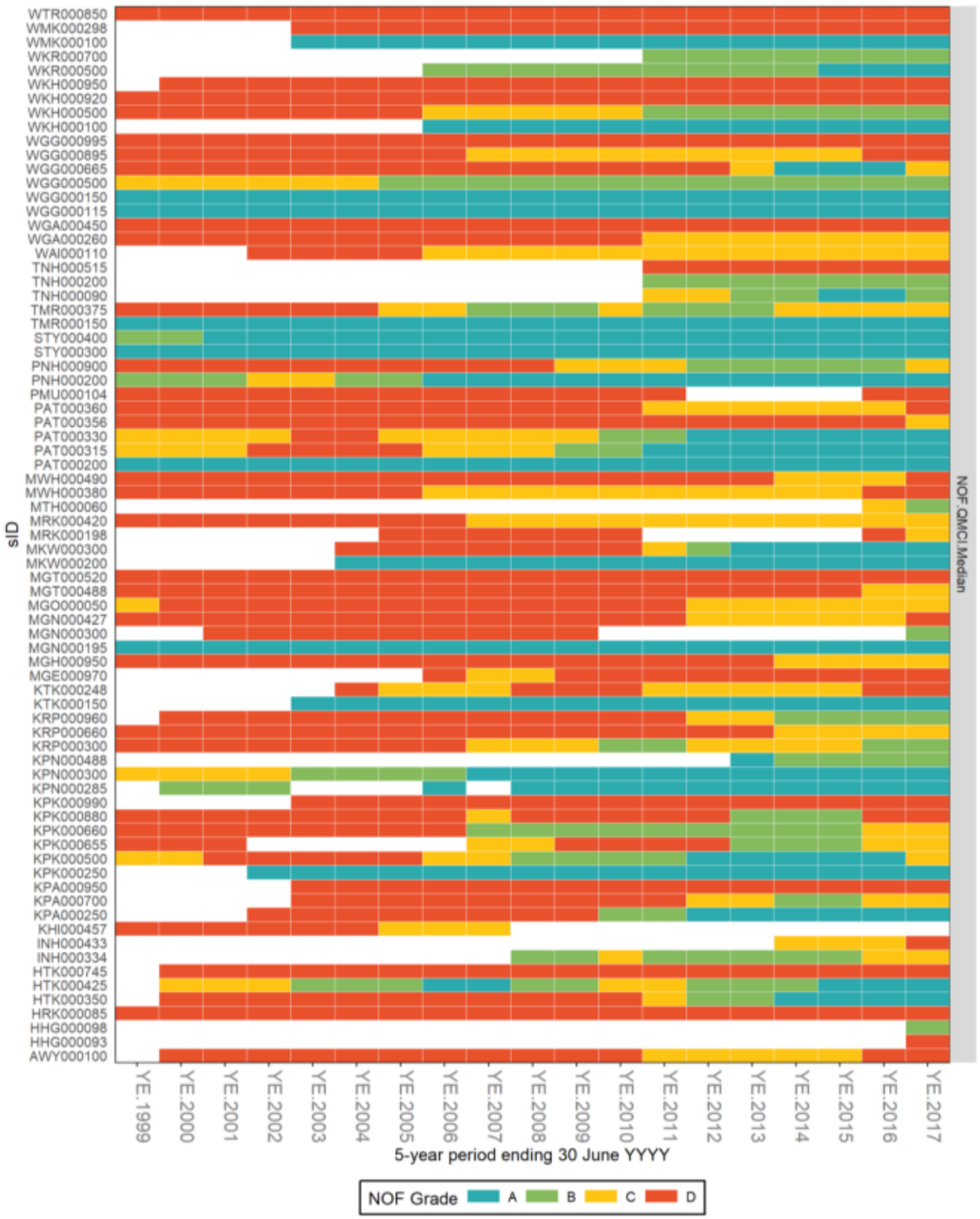

Figure 5: Temporal variation in NOF attribute bands for QMCI at a sub-set of monitoring sites from 1999 to 2017 from 'Taranaki water quality state spatial modelling' (Fraser, 2022).

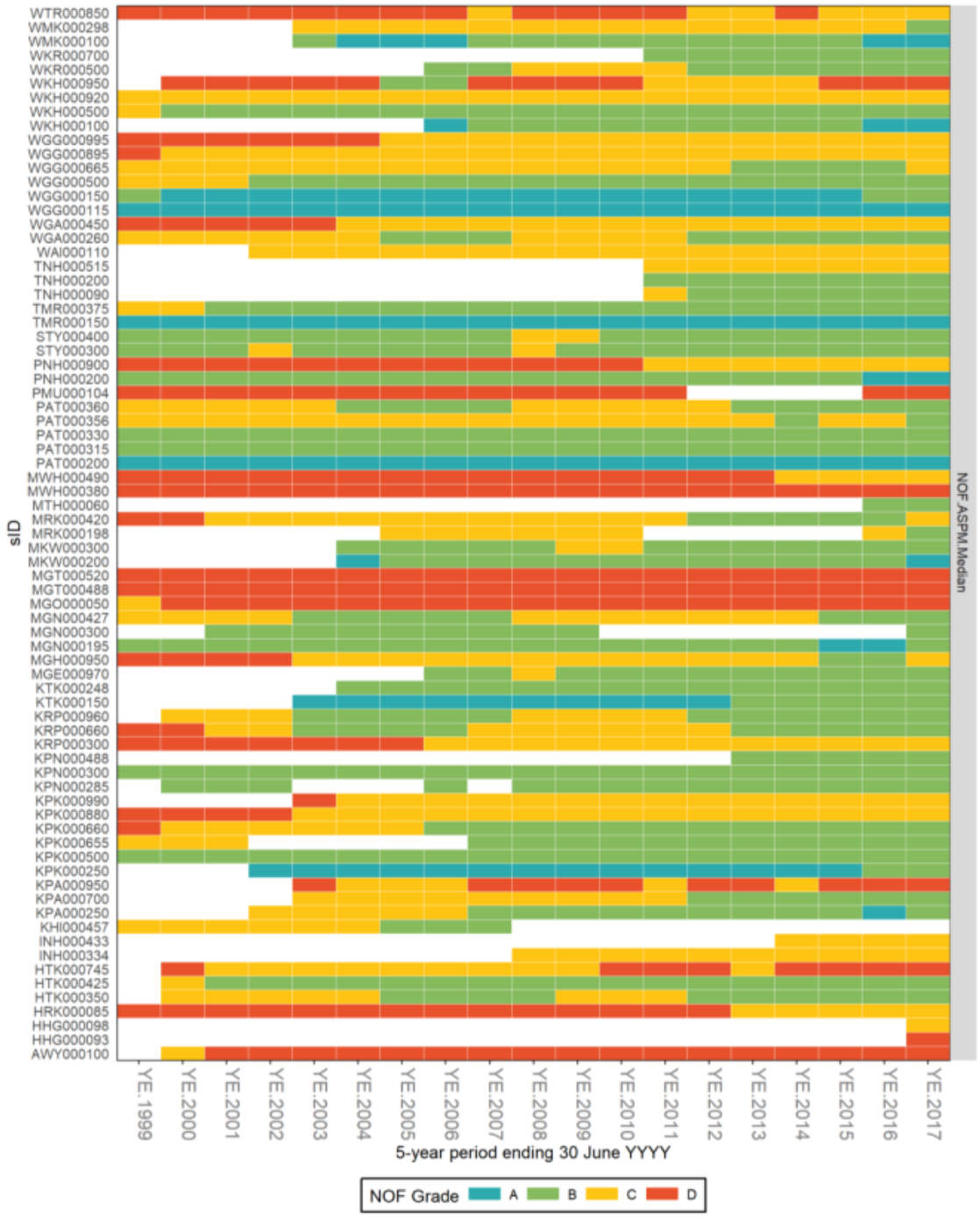

Figure 6: Temporal variation in NOF attribute bands for ASPM at a sub-set of monitoring sites from 1999 to 2017 from 'Taranaki water quality state spatial modelling' (Fraser, 2022).

Freshwater Management Unit (FMU) coverage and representativeness

An overarching requirement of the NOF framework is for councils to identify Freshwater Management Units (FMU). This extends to monitoring programmes needing to include a sufficient number of sites so as to be representative of that FMU. Should macroinvertebrate communities within an FMU, or communities at monitoring sites representing an FMU become degraded (or are identified as likely degrading), the Council must take action to stop or reverse degradation and improve the health of those macroinvertebrate communities.

The TRC macroinvertebrate SoE programme has responded to these requirements of the NPS-FM through the addition of new sites in an attempt to improve monitoring and representativeness of sites within the proposed FMUs. As part of a 2023 interim review of the SoE Macroinvertebrate Monitoring Programme, Riverwise Consulting carried out an assessment of the current network design.

A comparison of site representation in each proposed FMU from this report is shown in Figure 7 below. This assessment shows the proportion of the Taranaki region's total stream length found in each FMU, and compares this with the proportion of sites monitored in each FMU through the current macroinvertebrate SoE programme. This indicates that the Volcanic Ringplain and Coastal Terraces FMUs are over-represented in the SoE programme, while the Northern Hill Country, Pātea Catchment, and Southern Hill Country FMUs are under-represented. The number of sites currently monitored in the Waitara FMU is proportional to the overall stream length within the catchment.

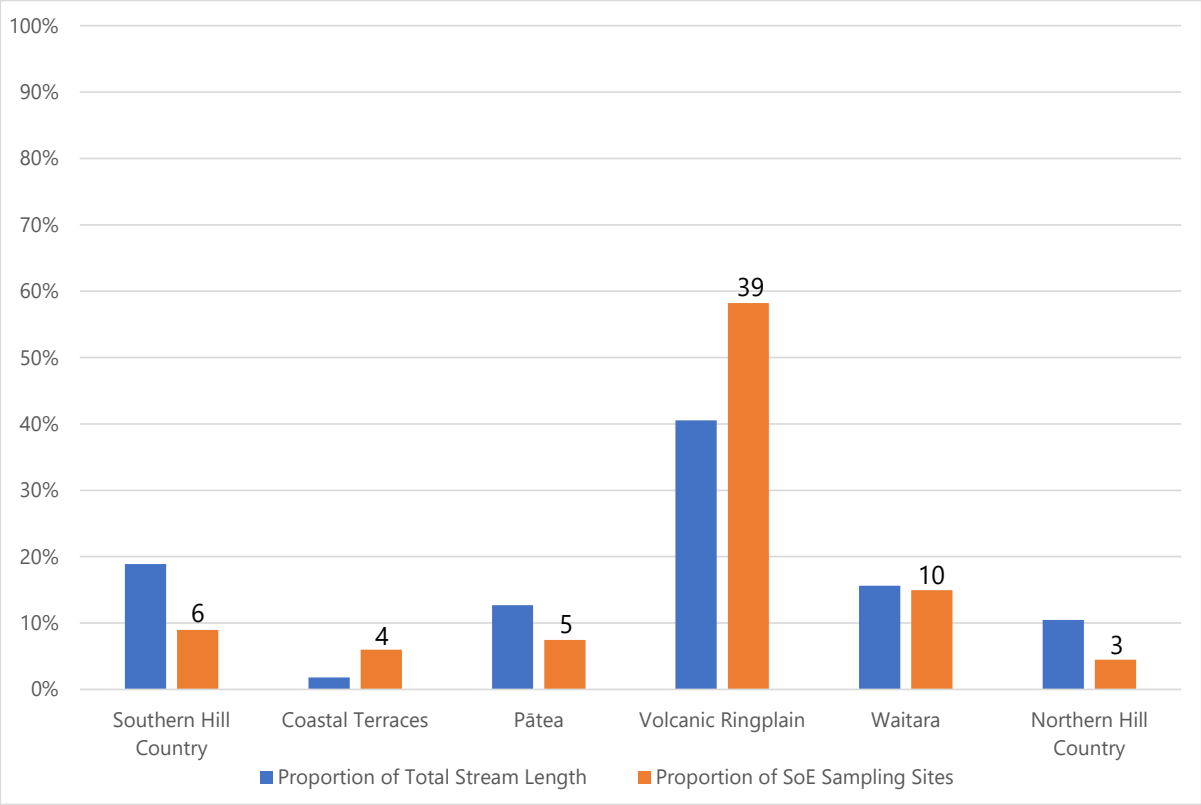

Figure 7: The proportion of total Taranaki stream length found in each FMU, compared with the proportion of macroinvertebrate sampling sites present in each FMU. The data labels represent the number of SoE sites in each FMU.

While this comparison provides a broad view, it does not recognise that there is a wide variation of streams and stream characteristics within each of these FMUs. The report by Riverwise Consulting provided further insight by applying River Environment Classification (REC) data to their assessment. The REC is a database of catchment spatial attributes, summarised for every segment in New Zealand's network of rivers.

Their analysis (Figure 8) shows that the network is reasonably representative of different climate conditions, geology, landcover and source of flow (elevation), although the network would benefit from greater representation of areas of indigenous forest, and soft sedimentary geology such as that found in the Southern and Northern Hill Country. It also suggests that the network would benefit from greater representation of lower order (small) streams.

Lower order streams (headwater streams) are an important component of any stream catchment. Fluxes of water and their constituents (e.g., sediment) move rapidly through lower order streams, and together they provide (amongst other things) a significant proportion of the flow and instream habitat and are often the

first receptor of contaminant runoff or groundwater sourced nutrients. Middle order streams are the tributaries where these headwaters meet. These tributaries feed into the high order main stems, which have large upstream catchments and storage where the variation in concentration and changes of inputs (e.g., contaminants or sediment) is levelled through catchment storage and mixing throughout the upstream tributaries (Snelder et al., 2004). While lower order streams make up 75% of Taranaki streams, presently macroinvertebrate SoE sites represent just 18% of these streams. In contrast, 60% of the sites are located in middle order streams, which make up 19% of Taranaki's streams. Higher order streams, which make up 6% of Taranaki's streams, contain 22% of the monitored sites.

With regard to SoE macroinvertebrate sites and FMUs, a closer examination of site distributions across stream sizes shows that lower order streams are under-represented in all FMUs, with the exception of the Northern Hill Country. It is notable that there are no sites located in lower order streams within the Pātea Catchment or Southern Hill Country FMUs.

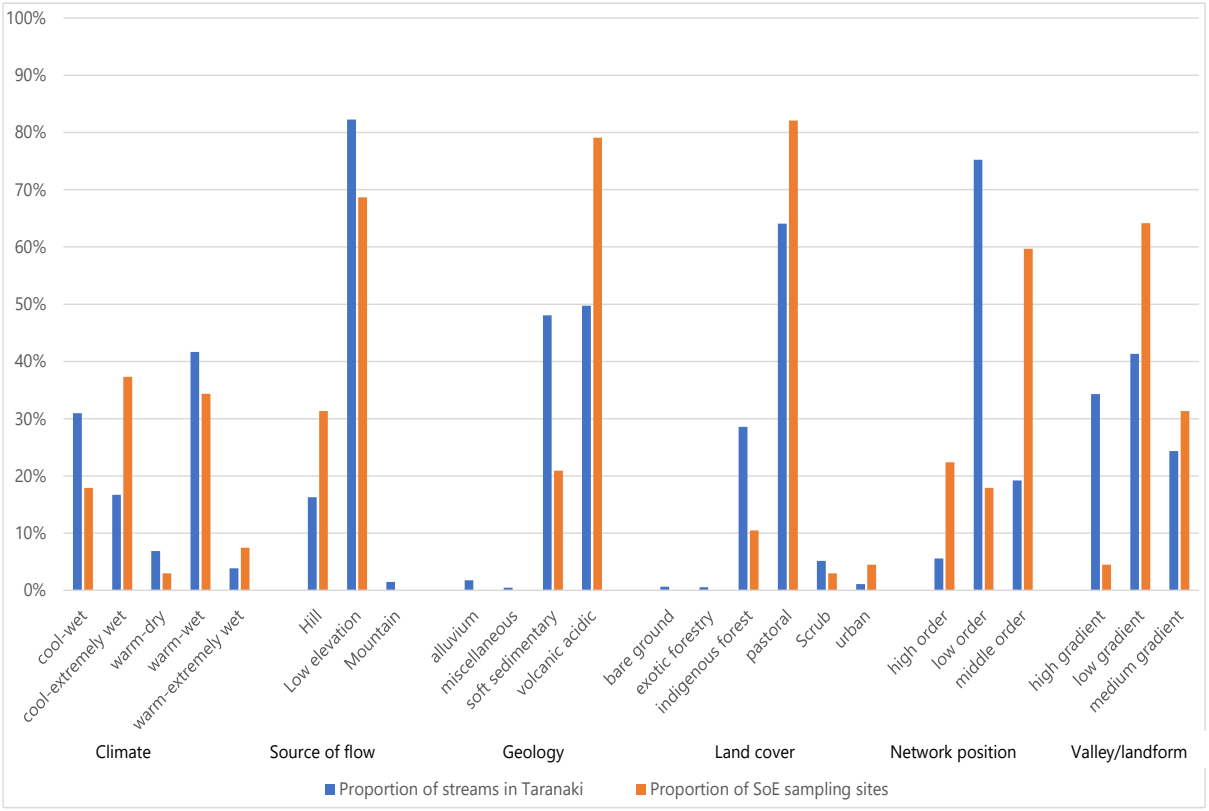

Figure 8: The proportion of total Taranaki stream length found in each REC class, compared with the proportion of macroinvertebrate sampling sites present within each class.

FMU-based baseline states

While there is a significant amount of macroinvertebrate monitoring carried out in Taranaki, there are limitations as to how well the data can describe current state at the FMU scale. To help address these limitations, modelling has been used to make predictions of the baseline state for each macroinvertebrate metric, at the river reach scale, across the entire Taranaki region. The modelling, carried out by Land Water People (LWP) (Fraser, 2022), provides a more representative, broad scale assessment of baseline state than is achievable based on monitoring data from individual sites alone. The modelled data is based on a digital drainage network of the Taranaki region that describes a range of descriptors of the individual network segments and their upstream catchment characteristics. There are six catchment characteristics that were included in the model: geography and topography, climate, hydrology, geology, land cover, and stocking density data.

The use of modelled data allows for an assessment of baseline states across both monitored and unmonitored waterways in the Taranaki region. Using modelled data, baseline states can be identified for each FMU, expressed as percentage waterway length in each FMU within each NOF attribute band.

In terms of available data and setting FMU-based baseline states, the use of macroinvertebrate SoE monitoring data alone has the potential to lead to biased conclusions given individual monitoring sites are non-random and are not entirely representative of the regional landscape and the pressures impacting on the health of the region's waterbodies. The TRC state spatial model thus provides the most comprehensive picture of the state of macroinvertebrate health across the entire regional stream network.

The site-based baseline states set using the long term SoE sites should be interpreted as site-specific and results are not necessarily indicative of the overall FMU state, while the modelled data and FMU-based baseline states portray patterns at a broader spatial scale and can be interpreted as applying to a section of river segments in an FMU, rather than a specific monitoring site.

FMU-based baseline states (expressed as percentages of stream lengths) for the macroinvertebrate numeric attribute states are shown in Table 6. Maps of stream widths under each NOF band for all three numeric attribute states are in Figure 9, Figure 10 and Figure 11.

Table 6: FMU-based baseline states for the macroinvertebrate numeric attribute states (MCI, QMCI, ASPM) expressed as percentage waterway length in each FMU within each NOF attribute band.

NOF Band	No. sites	MCI				QMCI				ASPM			
		A	B	C	D	A	B	C	D	A	B	C	D
Southern Hill Country	6	22.1%	45.1%	27.6%	5.1%	4.7%	58.7%	36.5%	0.1%	0.0%	40.7%	53.8%	5.5%
Coastal Terraces	4	0.0%	0.0%	54.5%	45.5%	0.0%	0.0%	97.9%	2.1%	0.0%	0.0%	46.3%	53.6%
Pātea	5	12.5%	50.9%	35.4%	1.3%	2.7%	37.9%	55.1%	4.3%	1.2%	33.4%	64.7%	0.8%
Volcanic Ringplain	39	14.1%	15.9%	68.2%	1.7%	17.4%	20.6%	59.7%	2.2%	7.8%	35.6%	52.7%	3.9%
Waitara	10	19.1%	45.2%	34.9%	0.8%	9.8%	35.6%	49.0%	5.6%	4.8%	56.6%	37.5%	1.1%
Northern Hill Country	3	20.6%	64.1%	15.2%	0.0%	0.0%	54.3%	45.0%	0.7%	0.0%	50.3%	43.2%	6.5%

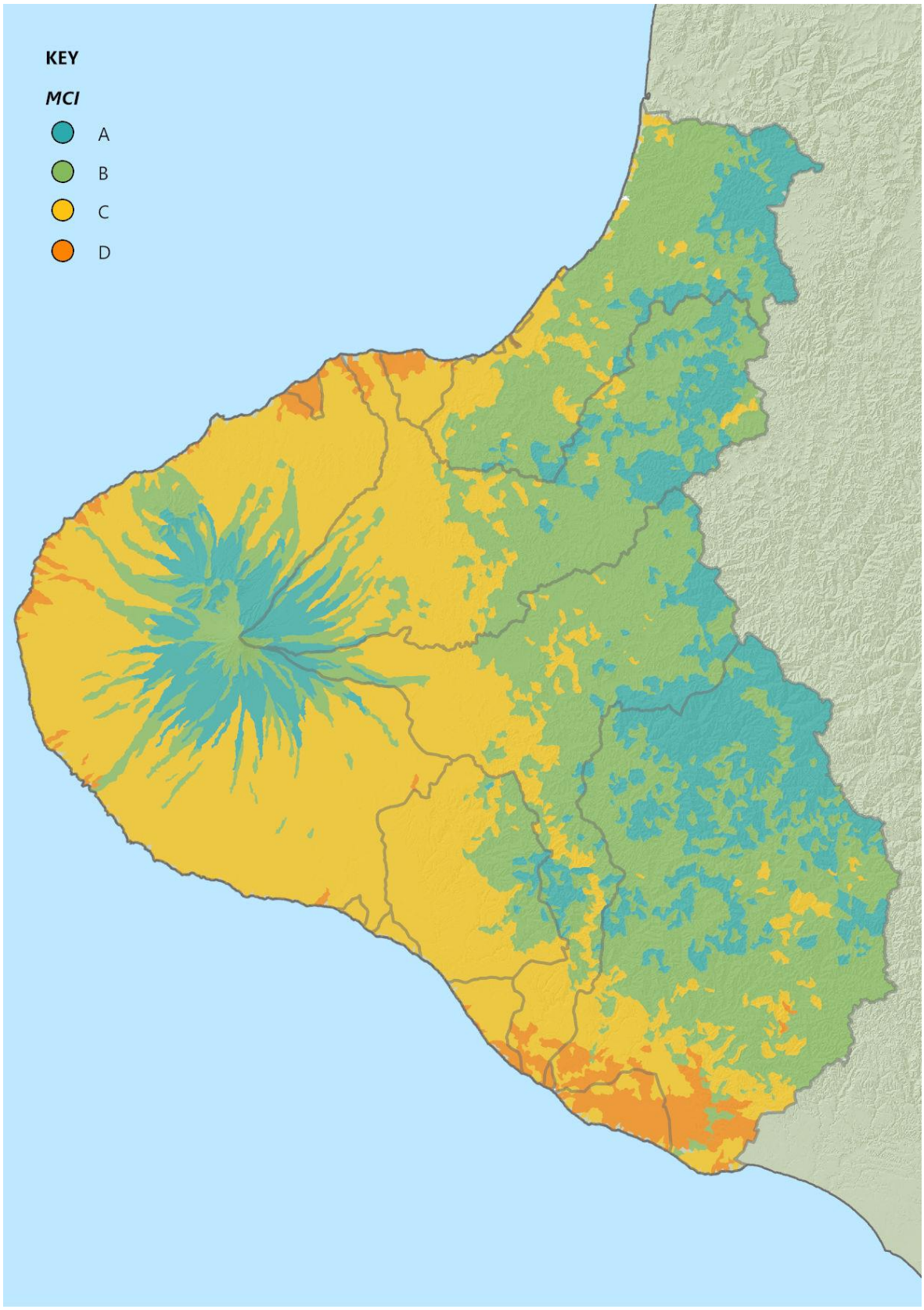

Figure 9: MCI baseline states of stream lengths in the Taranaki region using modelled data.

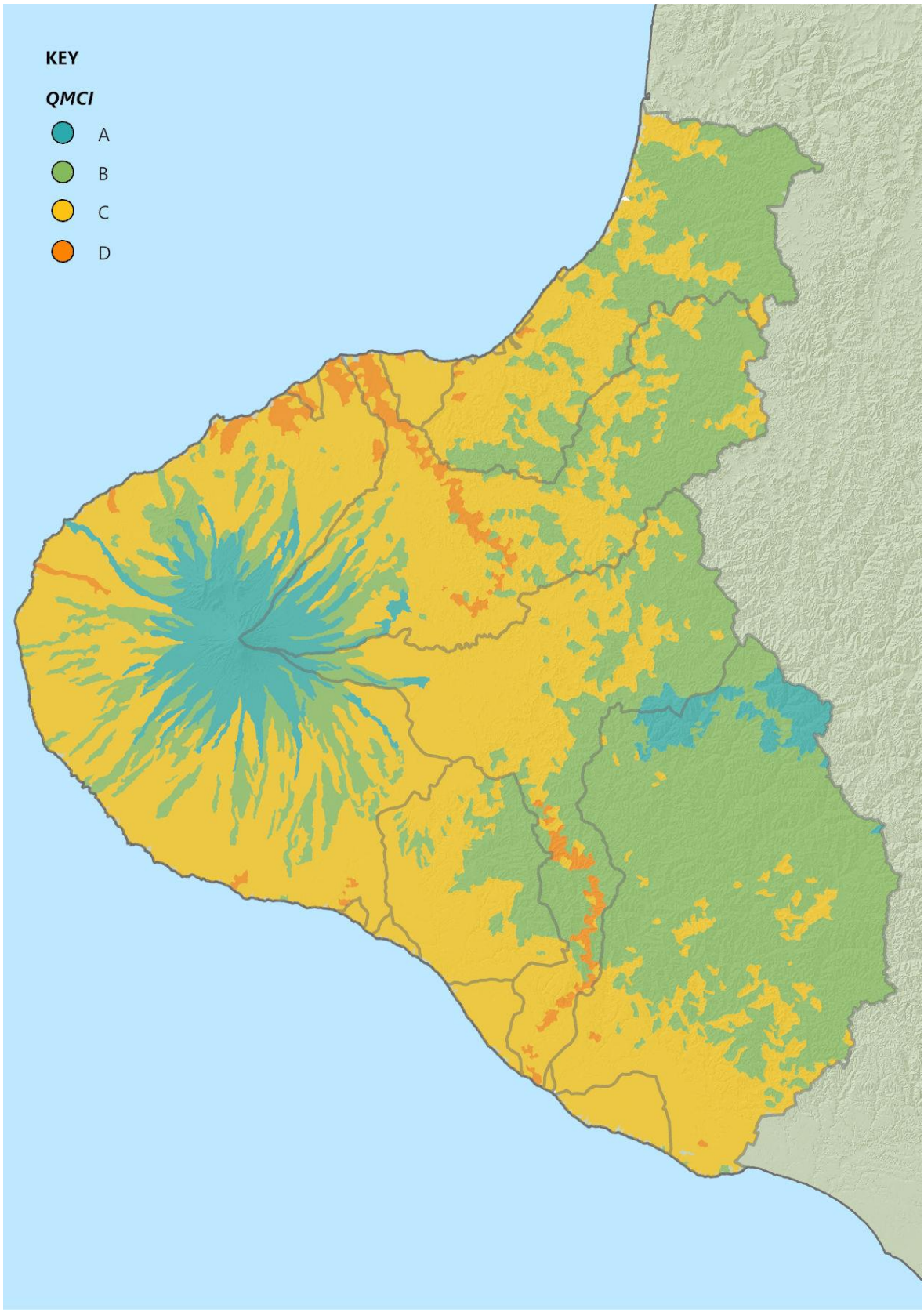

Figure 10: QMCI baseline states of stream lengths in the Taranaki region using modelled data.

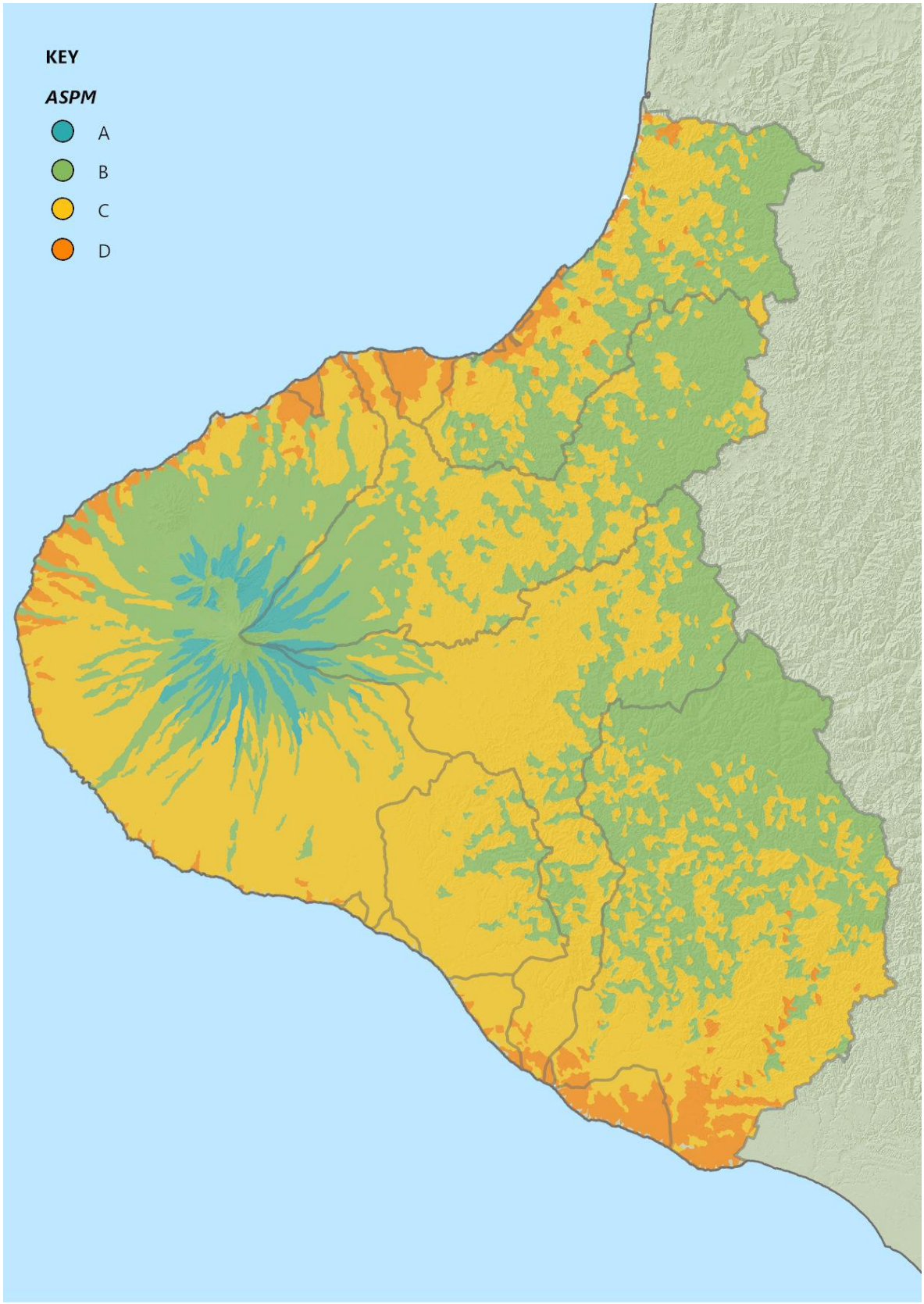

Figure 11: ASPM baseline states of stream lengths in the Taranaki region using modelled data.

Recommendations

Draft baseline states have been calculated for both monitoring sites and the overall stream network, to provide the best known state for macroinvertebrate attributes as indicators of ecosystem health across each FMU.

Consideration should be given towards setting target attribute states at broader spatial scales (e.g. at catchment or FMU scale) in addition to specified monitoring sites, given the available spatial modelling information. This approach recognises that environmental outcomes are intended to be achieved for all waterbodies rather than only at a select few monitoring sites. Target attribute states will need to be set at a level that (at a minimum) achieves the baseline state, or exceeds the baseline state where this is necessary to achieve improvement.

To support the target setting process, possible actions and mitigations that are available to promote the maintenance and improvement of freshwater in relation to macroinvertebrate communities (and ecosystem health more broadly) must be identified and assessed. This work is currently underway, with a range of contaminant source models under development to assess the impact of various mitigation actions on in-stream concentrations of nitrogen, phosphorous, sediment and *E. coli*. As an extension of this modelling, consideration should be given to the contaminant load reductions that are necessary to maintain or improve macroinvertebrate community health. National nutrient guidelines are currently being developed to assist with setting in-stream concentration limits to support macroinvertebrate communities.

The SCAMP (Simplified Contaminant Allocation Modelling Platform) model that is being developed for Taranaki by LWP Ltd and RMA Science Ltd will help to assess the impacts of a range of mitigation scenarios on nutrient concentrations in rivers and streams (Cox et al., 2022). The existing mitigations that are already being investigated include the completion of riparian fencing and planting throughout the region, and redirecting all dairy effluent discharges from water to land. Further scenarios are also being considered, including implementation of other mitigation actions associated with good farm management practise, as well as a range of possible future mitigation measures. Considering a broad range of possible mitigation actions for improving water quality will help to inform the target setting process by providing an indication of what can realistically be achieved under different scenarios.

Consideration should be given to improving regional representativeness of monitoring sites. However, this will need to be considered and prioritised alongside the additional monitoring requirements that have been identified for the remaining freshwater monitoring network.

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Appendix A: Macroinvertebrate state of environment monitoring sites used for baseline identification within each FMU

Freshwater Management Unit (FMU)	River/stream	Site name	Site code	River Environment Classification (REC)class	Location	
					Easting	Northing
Southern Hill Country	Moumahaki Stream	Moumahaki at Johnston Rd	MMK000050	WW/L/SS/P/MO/LG	1745684	5598975
	Tangahoe River	Upper Valley	TNH000090	WW/L/SS/P/MO/LG	1725340	5626101
		Tangahoe Vly Rd bridge	TNH000200	WW/L/SS/P/HO/LG	1719126	5622681
		D/S rail bridge	TNH000515	WW/L/SS/P/HO/LG	1715751	5612470
	Waiau Stream 2	Approx 1.2 km U/S of Hawkin Rd	WIU000700	WD/L/VA/P/MO/LG	1744324	5590101
	Whenuakura River	Nicholson Rd	WNR000450	WW/L/SS/P/HO/LG	1732757	5598479
Coastal Terraces	Mangaroa Stream	Vanners landfarm, Lower Ball Road	MRO000210	WD/L/VA/P/MO/LG	1720698	5602911
	Mangati Stream	D/S railway line	MGT000488	WN/L/VA/P/LO/LG	1700095	5678043
		Te Rima Pl, Bell Block	MGT000520	WW/L/VA/U/LO/LG	1699385	5679103
	Waiau Stream	Inland North Road	WAI000110	WW/L/VA/P/MO/LG	1714587	5680018
Pātea	Mangaehu River	Raupuha Rd	MGH000950	CW/L/SS/P/HO/LG	1726300	5639062
	Makuri Stream	30m D/S Raupuha Rd	MKR000495	WW/L/SS/P/MO/LG	1723795	5641478
	Pātea River	Barclay Rd	PAT000200	CX/H/VA/IF/MO/MG	1702620	5646598
		Swansea Rd	PAT000315	CX/H/VA/P/MO/LG	1711801	5644382
		Skinner Rd	PAT000360	CW/L/VA/P/HO/LG	1715919	5644681
Volcanic Ringplain	Herekawe Stream	Centennial Drive	HKR000085	WW/L/VA/U/MO/MG	1688283	5674972
	Huatoki Stream	Hadley Drive	HTK000350	WX/L/VA/P/MO/LG	1693349	5671486
		Huatoki Domain	HTK000425	WW/L/VA/P/MO/LG	1693041	5673404
		Molesworth St	HTK000745	WW/L/VA/U/MO/MG	1692800	5676424
	Kapoaiaia Stream	Wiremu Road	KPA000250	CX/H/VA/P/MO/MG	1678009	5652025
		Wataroa Road	KPA000700	CX/H/VA/P/MO/MG	1672739	5652272
		Cape Egmont	KPA000950	CX/L/VA/P/MO/LG	1665690	5652452
	Kaupokonui River	Opunake Road	KPK000250	CX/H/VA/IF/MO/MG	1698088	5639231
		U/S Kaponga oxi ponds	KPK000500	CX/H/VA/P/MO/MG	1698609	5634423
		U/S Lactose Co.	KPK000660	CX/H/VA/P/MO/LG	1697613	5629791
		Upper Glenn Road	KPK000880	CW/H/VA/P/MO/LG	1693026	5622705
		Near mouth	KPK000990	CW/L/VA/P/HO/LG	1691209	5620444
	Katikara Stream	Carrington Road	KTK000150	CW/L/VA/P/HO/LG	1683566	5657855
		Beach	KTK000248	WX/L/VA/P/MO/LG	1676597	5667473
	Mangorei Stream	SH3	MGE000970	CX/L/VA/P/MO/LG	1696094	5671500
	Mangaoraka Stream	Corbett Road	MRK000420	WW/L/VA/P/MO/LG	1702538	5676320

Freshwater Management Unit (FMU)	River/stream	Site name	Site code	River Environment Classification (REC)class	Location	
					Easting	Northing
Volcanic Ringplain	Mangawhero Stream	D/S Mangawharawhara S	MWH000490	CN/L/VA/P/MO/LG	1710795	5632738
	Punehu Stream	Wiremu Rd	PNH000200	CX/H/YA/IF/MO/MG	1687323	5637020
		SH45	PNH000900	CW/L/VA/P/MO/LG	1677946	5627786
	Hangatahua (Stony) River	Mangatete Road	STY000300	CX/H/VA/S/MO/MG	1677460	5657823
		SH45	STY000400	CX/H/VA/S/MO/MG	1674632	5661558
	Timaru Stream	Carrington Road	TMR000150	CX/H/VA/IF/LO/HG	1684423	5659634
		SH45	TMR000375	CX/L/VA/P/MO/MG	1679509	5665554
	Waiongana Stream	SH3a	WGA000260	CX/L/VA/P/MO/LG	1705159	5669554
		Devon Road	WGA000450	WW/L/VA/P/MO/LG	1704063	5680381
	Waingongoro River	700m D/S Nat Park	WGG000115	CX/H/VA/IF/LO/MG	1700835	5645086
		Opunake Rd	WGG000150	CX/H/VA/P/LO/MG	1705692	5642523
		Eltham Rd	WGG000500	CW/L/VA/P/MO/LG	1710576	5634824
		Stuart Rd	WGG000665	CW/L/VA/P/HO/MG	1709784	5632049
		SH45	WGG000895	CW/L/VA/P/HO/LG	1704042	5618667
		Ohawe Beach	WGG000995	CW/L/VA/P/HO/MG	1702531	5617624
	Waiwhakaiho River	National Park	WKH000100	CX/H/VA/IF/LO/HG	1696096	5658351
		SH3 (Egmont Village)	WKH000500	CX/H/VA/P/MO/MG	1698297	5666893
		Constance St (NP)	WKH000920	CX/H/VA/P/HO/LG	1695827	5677271
		Adjacent to L Rotomanu	WKH000950	CX/H/VA/P/HO/LG	1696587	5678336
	Waiokura Stream	Skeet Rd	WKR000500	WW/L/VA/P/MO/LG	1698807	5628892
		Manaia Golf Course	WKR000700	WW/L/VA/P/MO/LG	1697636	5622019
	Waimoku Stream	Lucy's Gully	WMK000100	WW/L/VA/P/LO/HG	1681324	5666240
		Beach	WMK000298	WW/L/VA/P/MO/MG	1681725	5669851
Waitara	Kurapete Stream	U/S Inglewood WWTP	KRP000300	WX/L/VA/P/LO/LG	1705087	5665510
		D/S Inglewood WWTP	KRP000660	WW/L/VA/P/LO/LG	1709239	5667481
	Makara Stream	120m U/S confluence with Waitara River	MAA000900	WW/L/SS/P/MO/MG	1717268	5669453
	Manganui River	SH3	MGN000195	CX/H/VA/P/MO/LG	1708871	5651282
		Bristol Road	MGN000427	CX/L/VA/P/HO/MG	1711210	5667887
	Maketawa Stream	Opp Derby Road	MKW000200	CX/H/VA/IF/MO/MG	1702192	5656304
		Tarata Road	MKW000300	CX/H/VA/P/MO/LG	1708784	5665231
	Matau Stream	U/S confluence with unnamed trib.	MTA000068	CW/L/SS/P/LO/MG	1733965	5661062
	Waitara River	Autawa Road	WTR000540	WX/L/SS/P/HO/LG	1720719	5663669
		Mamaku Road	WTR000850	WX/L/SS/P/HO/LG	1708384	5678739

Freshwater Management Unit (FMU)	River/stream	Site name	Site code	River Environment Classification (REC)class	Location	
					Easting	Northing
Northern Hill Country	Mangaoreti Stream	U/S of Avenue Rd Bridge	MNT000950	WW/L/SS/P/LO/LG	1722557	5682900
	Uruiti River	SH3 Bridge	URU000198	WW/L/SS/P/MO/LG	1732463	5688339
	Waikaramarama Stream	Waikaramarama Road - D/S of first bridge	WMR000100	WW/L/SS/P/LO/LG	1730866	5692865